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Pelagic Fisheries Research Program

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# Quantifying Sea Turtle Mortality with PSATs

*Yonat Swimmer, Richard Brill and Michael Musyl*

*The incidental capture of marine turtles in longline fishing gear is generally accepted to be a significant factor contributing to the decline of sea turtle populations in both the Pacific and Atlantic Oceans (Heppell et al., 1999; NMFS, 2001a). Pelagic-stage juvenile hard-shelled turtles (e.g., Loggerheads,* Caretta caretta*) are generally hooked in the mouth, presumably because they have bitten baited hooks (Figures 1 and 2), whereas Leatherback turtles (*Dermochelys coriacea*) are most often hooked in the flippers or entangled in fishing lines.*

*While most turtles that interact with longline gear are eventually released alive, they are often released with hooks remaining in their mouths, throats, gastrointestinal tracts or flippers (Aguilar et al., 1995; Oravetz, 1999). The ultimate effects of these hooks and the stress of capture are unknown. Rates of post-release mortality have not yet been adequately quantified, and available estimates are highly controversial. Given the growth in U.S.-permitted longline fishing vessels in both the Pacific and Atlantic over the past two decades (Hoey, 1996; Ito and Coan, 1999), the question of post-release mortality rates holds growing importance.*

The assessment of sea turtle mortality attributed to hooking or entanglement is difficult. Current estimates are based on a combination of known recorded mortality (i.e., turtles dead upon retrieval of longline gear), cessation of transmissions from satellite tags (Parker et al., in press), and captive studies in which turtles hooked on longlines were placed in tanks and observed over time (Aguilar et al., 1995). Needless to say, mortality estimates are extremely variable (ranging from 8 to 95% for Loggerheads and Leatherbacks), thus making it impossible to define a reasonable overall mortality rate following interactions with longline fishing gear (Aguilar et al., 1995; McCracken, 2000; NMFS, 2001b).

Our goal is to quantify the rates of mortality and morbidity in turtles released from longline gear by using state-of-the-art pop-up satellite archival tags (PSATs). PSATs record data on swimming depth, water temperature and daily estimated geolocation (Musyl et al., 2001; Hill and Braun, 2001). Originally designed to track the movement of large pelagic fish (Lutcavage et al., 1999; Arnold and Dewar, 2001), PSATs can be programmed to release and download data up to two years after deployment, providing a record of long-term movement patterns and associated physical environments.

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**Figure 1. A subadult Olive Ridley Sea Turtle (*Lepidochelys olivacea*) hooked in longline fishing gear (photo by Yonat Swimmer).**

More important, however, PSATs will release and begin transmission of stored data if a turtle dies and sinks, or if its tag is shed. Therefore, unlike conventional satellite tags, PSATs provide data that clearly differentiate mortalities from shed tags. Depth data collected by the tags can also be used to determine the extent of morbidity following release. Once at the surface, the tag will download its archived data to a satellite (including the pop-off location directly determined by ARGOS). Some of the tags can conserve battery power by transmitting only when the satellite is in view (SIV). For a tag that has collected data for a year, it normally takes two to three weeks for the archived data to be downloaded.

## PSAT Utility and Longevity

In the absence of any mechanical/electronic failure or unusual biological event (e.g., a tag is eaten by a shark), we are confident about the usefulness of PSATs for differentiating a shed tag from a mortality. Our confidence is based partly on earlier successes with tagging blue sharks (*Prionace glauca*). In a collaborative effort between the University of Hawai'i and the NMFS, 14

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**Figure 2. Longline hook removed from lower jaw of an Olive Ridley Sea Turtle in Costa Rica (photo by Yonat Swimmer).**

sharks were tagged with PSATs in the Central Pacific following capture by longline gear (see also PRFP Newsletter, July-September 2001, pp. 13-14). The tags were programmed to release at a depth of 1,200 m, which is beyond the depth blue sharks would normally reach (Scarotta and Nelson, 1977; Carey and Scharold, 1990). The depth-data record from one male shark is shown in Figure 3. The animal clearly exhibited normal movement patterns for the first five days following release. After this it succumbed, presumably to injuries sustained during the interaction with longline fishing gear. This is clearly evidenced by the plummeting descent of the PSAT followed by a rapid ascent after automatic release at the programmed depth of 1,200 m. We believe similar tag programming and function will be useful to indicate mortality in marine turtles.

**Figure 3. Depth data for a male blue shark (*Prionace glauca*) tagged with a PSAT around the Hawaiian Islands in April 2001. Data are not recorded in consecutive time intervals due to the PSAT's duty cycle, which is approximately one day on and one day off.**

Given their longevity, PSATs also enable researchers to determine the long-term movement patterns of turtles, and the nature of their physical environments (i.e., to correlate data on the turtles' dive-depth profiles and migratory routes with information on currents, sea surface temperatures, and primary productivity, collected simultaneously by satellites). Collection of long-term data will, in turn, allow design of time-area fishery closures that are effective in reducing rates of interaction between turtles and longline gear, but that are likewise acceptable to fishermen.

We are currently employing PSATs designed by both Microwave Telemetry, Inc. (Columbia, Md., USA; www.microwavetelemetry.com) and Wildlife Computers (Redmond, Wa., USA; www.wildlifecomputers.com). Algorithms used to estimate geographic positions from PSAT data are currently assumed to allow accuracy of ± 0.5° longitude and ± 1.0° latitude (Musyl et al., 2001). But double-tagging studies (i.e., placing both conventional platform terminal transmitters [PTTs] and PSATs on the same animal) are currently underway on Leatherback turtles. The resulting data should allow us to better determine, and eventually further refine, the accuracy of light-based algorithms for providing daily geopositions for moving pelagic animals.

## Attaching PSATs to Hard-Shelled Turtles

As PSATs had never before been used on marine turtles, our first task was to devise a method of attachment that would be strong, long lasting, and non-harmful. This method had to be easy and reliably employed, even by inexperienced fisheries observers working in the difficult conditions associated with small (generally less then 30 m) U.S. commercial longline vessels operating on the high seas. To meet all these requirements, we designed a baseplate that could be glued to the turtle's carapace, and attached via tether to the PSAT (Figure 4). As the baseplate must be resistant to crushing and loss of buoyancy at depth, we decided on a syntactic foam designed to maintain its buoyancy down to 2,500 m. The material, manufactured by Syntech Materials, Inc. (Springfield, Va., USA; www.syntechmaterials.com) is relatively inexpensive and easily fabricated into any shape using common tools.

We did find, however, that the length of the tether was critical. It had to be long enough that the PSAT would float with its antenna upward to allow successful transmission to a satellite in the event that the tag was shed with the baseplate attached (Figure 5). Using a 270-pound-test fluorocarbon line, we found the minimum tether length to be 28 cm. To attach the PSAT and baseplate to the tether, we used stainless steel crimps (from Nicopress Inc.; The National Telephone Company, Cleveland, Oh., USA; www.nicopress.thomasregister.com) that are matched to the diameter of the fluorocarbon line.

Most important, we found a simple marine epoxy to be highly suitable for attachment of the baseplate to the carapace of hard-shelled turtles (Marine Fix® Fast, by Eclectic Products Inc., Houston, Tx., USA; www.webhorizon.com/am/Eclectic_Products Frame1Source1.htm). It is inexpensive and available at marine

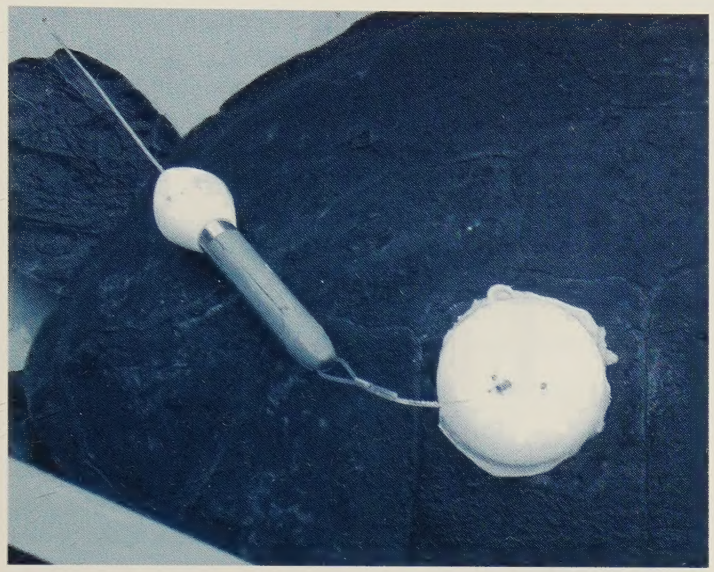

**Figure 4. A syntactic foam baseplate mounted on a turtle's carapace. A fluorocarbon tether, connected with stainless steel crimps, attaches the baseplate to the PSAT (photo by Yonat Swimmer).**

supply and home improvement stores. The two parts of the epoxy are mixed and spread on the flat side of the baseplate, which is then gently pressed onto a relatively flat portion of the carapace. Depending on ambient temperature, the epoxy generally hardens enough within one hour for the turtle to be released. Moreover, the epoxy will cure and adhere even if wet. However, in order to prevent the tag from sinking if it is shed, the amount of epoxy used should be monitored; for example, with a 3-in diameter baseplate, no more than ~165 g of epoxy should be used. Furthermore, as the two-part epoxy needs only to be mixed in equal proportions, it is simpler to use than fiberglass resin. Our procedures and relevant observer training manual have been reviewed and approved by the NMFS Office of Protected Species.

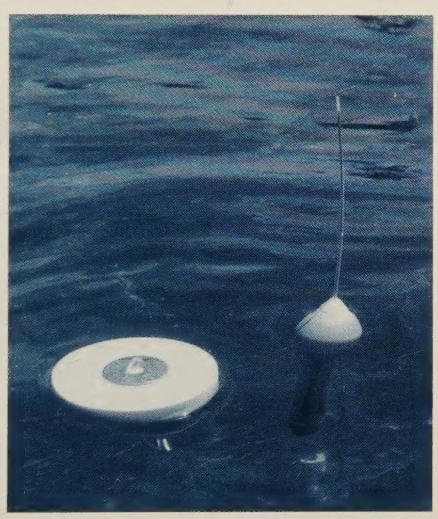

**Figure 5. If the PSAT and baseplate are shed from the turtle, successful transmission to a satellite requires that the tether be long enough for the tag to float with its antenna upwards (photo by Yonat Swimmer).**

We have confirmed the suitability of this epoxy using four subadult Green Sea Turtles maintained in captivity at the NOAA/NMFS Honolulu Laboratory Kewalo Research Facility (Figure 6). We found the dummy PSATs would remain attached for up to nine months, but that the baseplates could be removed by a firm tug on the tether. In other words, we found that the epoxy and foam baseplate combination results in adequate adhesion to the carapace, yet still provides a margin of safety in that the PSAT will detach if it becomes entangled in marine debris. Just as important, we found no evidence of damage or obvious pathology in the area of the carapace covered by the baseplate, even after nine months.

## Practical Considerations and PSAT Limitations

PSATs are designed to be deployed at sea by scientific observers, many of whom have little or no experience with sea turtles. Therefore, the attachment method described above is designed to provide maximal safety both to the turtle and the person attaching the tag. Admittedly, there is some chance that epoxy-adhered PSATs may detach more readily than those tethered to baseplates that are "bolted" through the carapace, but we prefer that turtles have the ability to shed tags; the alternative is to risk that they become entrapped under a ledge or entangled in marine debris via PSATs that are affixed too tightly.

At present, the geolocation capabilities of PSATs are not as precise as conventional PTTs. Therefore, for research in which fine-scale location is required, PTTs are the more appropriate tool. For our purposes, however, one of the most important features of the PSAT is the ability to distinguish a tag shed at mortality, which usually is not possible with conventional satellite tags— and for this, we sacrifice some fine-scale geolocation resolution. Therefore, depending on the questions asked, a conventional tag

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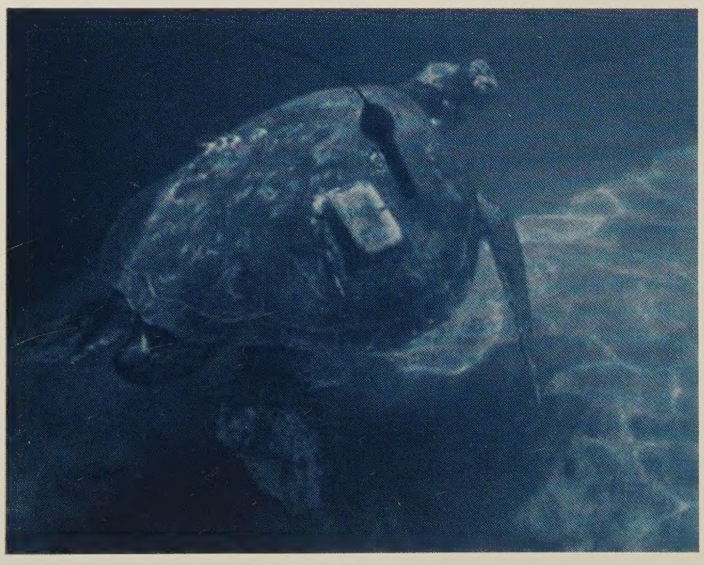

**Figure 6. A baseplate securely mounted on the carapace of a captive Green Sea Turtle (*Chelonia mydas*) using a simple marine epoxy; the hydrodynamic tag is designed to be pulled with minimal drag (photo by Yonat Swimmer).**

might be preferred to a PSAT. For example, for use on marine turtles that live primarily in the neritic, where fine-scale resolution of movement patterns is desired, and where entrapment under ledges may be more likely than in the pelagic environment, a small conventional PTT glued to the carapace would likely be a better choice.

## Successful Taggings at Sea

On July 28, 2001, an Olive Ridley (*Lepidochelys olivacea*) was brought aboard a Hawai'i-based commercial longline vessel after being hooked in the mouth. The hook was not retrievable. The observer on board successfully applied a PSAT and released the turtle at 19° 22' N, 160° 7' W. The turtle was at liberty for 82 days before the tag was shed. During that time it traveled from its point of release to 16° 1' N, 127° 30'W, indicating the turtle generally swam in a southwesterly direction (263°) and covered a straight-line distance of 1,874 nmi (Figure 7). Data generated for this graph have been analyzed using a state space Kalman filter statistical model, which was used to estimate geolocation errors, movement parameters and most probable tracks from the recovered data (Sibert et al., in press). Histograms of dive-depth profiles (Figure 8) indicate that during the day, the turtle spent nearly 60% of its time within the top 50 m, and only rarely exceeded depths of 250 m. During the night, the turtle remained in somewhat deeper water, spending nearly 45% of its time at depths of 10 to 100 m. The maximum recorded dive depth was 544 m, with a corresponding temperature of 4° C. More important, the data indicate that the turtle was still functioning normally after 4 months, in spite of the longline hook not being removed.

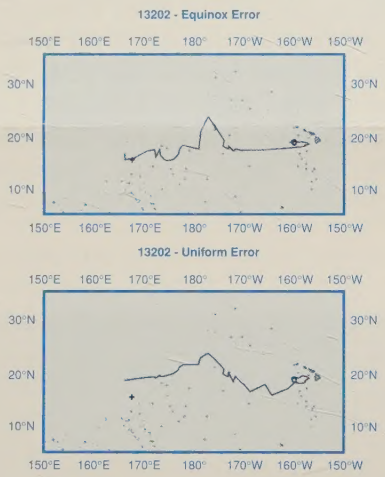


**Figure 7. Daily geolocation estimates for an Olive Ridley Sea Turtle caught on commercial longline gear, determined using a state space Kalman filter statistical model. The turtle was at liberty for 82 days from late July until mid-November 2001.**

To date, observers on Hawai'i-based commercial longline vessels have taken PSATs on more than 55 longline trips over the last seven months. Because of current court-ordered restrictions on gear-setting practices (designed to reduce turtle interactions), the turtle described above is the only one within our program tagged with a PSAT from the Hawai'i-based longline fleet.

Therefore, in an effort to tag more longline-caught turtles, we recently traveled to Costa Rica, where there is a substantial commercial longline fleet primarily targeting dolphin fish (dorado or mahimahi; *Coryphaena hippurus*) off the Pacific Coast.

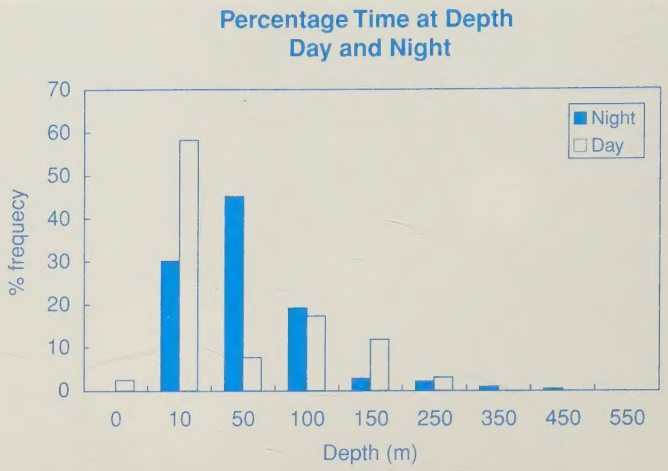


**Figure 8. Histograms of time at depth (day and night) for an Olive Ridley Sea Turtle caught and released from a commercial longline vessel operating near the Hawaiian Islands.**

This fleet experiences a relatively high bycatch of sea turtles (primarily juvenile Olive Ridleys). In collaboration with Randall Arauz (Central American Director, Sea Turtle Restoration Project), and with the full cooperation of the commercial longline fishermen, we were able to deploy PSATs on four longline-caught animals. The severity of injury due to hooking differed among the four turtles, and will eventually be correlated with data received from the PSATs. We also were able to capture three free-swimming juvenile Olive Ridleys. Turtles caught and tagged while free-swimming are especially valuable, as the data they generate will serve as controls against which to compare the behaviors (and possible mortalities) of hooked animals. The PSATs deployed were programmed to release after 6 or 12 months.

## Acknowledgments

We thank George Balazs, David Gremminger, Lianne Mailloux, Robert Morris, and the staff of the NMFS Marine Turtle Research Program for care and handling of the turtles. We sincerely appreciate the efforts of John Sibert, who processed our geolocation data through his Kalman filter. We acknowledge the NMFS-SWFSC Honolulu Laboratory and the University of Hawai'i Joint Institute for Marine and Atmospheric Research-PFRP for providing resources and funds to support this research. Opinions expressed are those of the authors and do not reflect the views of NOAA or NMFS. Mention of product names does not imply endorsement by NOAA or NMFS. Research on live animals was performed in accordance with all applicable laws and regulations of the United States.

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# New Discoveries in the Olfactory Capability of Sea Turtles

*Richard G. Vogt, Michelle Vieyra and Daniel Anderson*

*This is a preliminary report of results obtained in a continuing study of the sensory capabilities of sea turtles, conducted in collaboration with Dr. Richard Brill of the National Marine Fisheries Service. Funded through the Pelagic Fisheries Research Program, these experiments began in July 2001, and were performed in the Department of Biological Sciences at the University of South Carolina, Columbia.*

How important is the sense of smell to a sea turtle? And if it is important, can we make use of smell to more effectively manage turtle populations— for example, to reduce the numbers taking baited fishhooks? All organisms interpret and interact with the world through sensory systems, without which they could find no mates, avoid no predators, or locate no food.

The ability to detect chemicals, which we think of as smell and taste, is perhaps the oldest sense— present in bacteria since the beginning of life and in every organism since. Smell and taste are less different in what they detect in how the detection is accomplished. Humans smell and taste very different kinds of chemicals, but fish smell and taste very similar chemicals. One consistent difference between smell and taste is that each sends information to a different part of the brain. Another difference is the way in which smell and taste are used. In general, smell works from a distance, while taste works close up. For example, animals make food decisions in a hierarchical fashion: seeing and/or smelling something from a distance arouses interest, after which biting and tasting provides information about nutritional or toxic content. Making fish bait unattractive to sea turtles' noses might prevent them from contacting fishhooks altogether.

## How Are Odors Detected?

Odors are detected by proteins called odor receptors (ORs) embedded in the membranes of olfactory cilia, which protrude from olfactory sensory neurons (see Figure 1). The interactions between odor molecules and ORs are the all-important initial recognition step in odor detection. Supposedly, humans can discern 10,000 different odors, accomplished by having about 350 different ORs, each one individually expressed in about 1000 sensory neurons. Any given odor activates a small but unique combination of different ORs and neurons. Mice and rats accomplish this detection with about 1000 distinct ORs, and fish with about 100 ORs. In the evolution of vertebrates (see Figure 2) there has been an increase in the number of OR genes (fish have 100 ORs, mammals have 1000), as well as an occasional decrease in the numbers of genes that are actually functional.

## ORs and Olfactory Utility

A great deal is known about vertebrate ORs and OR genes; in particular, it is known that the structure of OR genes is very similar in vertebrates from fish to humans. We believe we can make use of this fact to assess in a non-invasive manner certain aspects of the sense of smell in threatened and endangered species. Our objective is to determine the value of smell-based strategies now being developed to manage these species.

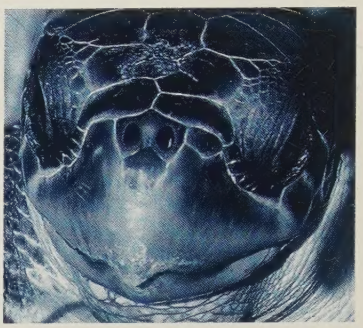

**Figure 1. Face of an Olive Ridley Sea Turtle showing prominent nasal openings to olfactory tissue. Turtle was rescued from longline fishhook off Costa Rica in November 2001. Photo courtesy of Richard Brill and Yonat Swimmer, NMFS, Honolulu.**

Scientists have isolated and characterized the DNA that encodes the proteins for many ORs in the coelacanth, 1 bird species, 2 frog and 1 salamander species, numerous mammal species, and several fish species (Figure 3). However, nothing is known of the ORs in turtles and reptiles. When vertebrate ORs are compared, very similar amino acid sequences are seen in specific regions of all, providing both hallmarks that help identify the sequences as ORs, and tools that are useful for cloning ORs from new species such as

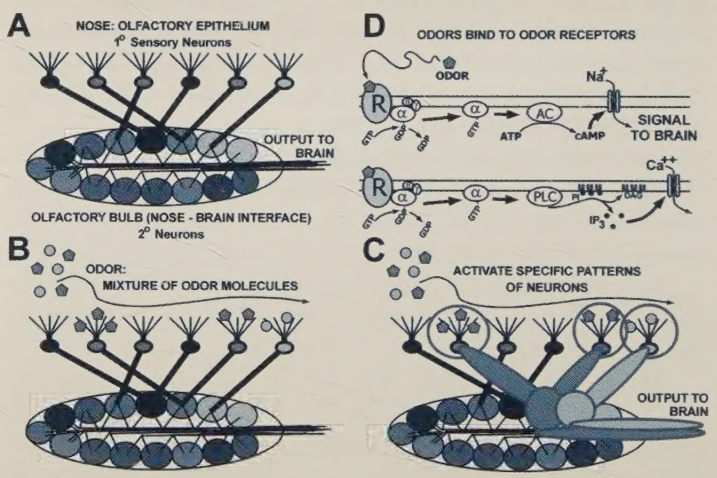


**Figure 2. In all vertebrates, odors are detected by primary sensory neurons in an olfactory epithelium located in the nose (A). The primary neurons connect to secondary neurons in the olfactory bulb in spherical structures called glomerulae; the secondary neurons send signals further into the brain. Odors are usually mixtures of different chemicals; each chemical is detected by a unique set of sensory neurons, which in turn connect to and activate a unique pattern of glomerulae and secondary neurons, sending a specific signal to the brain (B, C). Odor molecules bind to and activate Odor Receptor proteins (ORs) located in the membranes of the sensory neurons. The activated ORs then activate a biochemical pathway that generates an electrical signal (D). Interaction between odor molecules and ORs is the initial recognition step in odor detection. For more information, read the review by Hildebrand and Shepherd, 1997.**

turtles and reptiles. We arranged to have small pieces of DNA made that match these conserved regions of OR DNA, and used these pieces as primers in a technique called Polymerase Chain Reaction to amplify and clone OR genes; the genes come from genomic DNA isolated from the blood of Green, Leatherback and Loggerhead Sea Turtles, and the American Alligator.

This was entirely non-invasive— the blood samples were already in storage as part of ongoing population genetics studies used for the management of each species. A drop of one of these samples (about 0.2 ml) was all that was needed to identify many OR genes. While still preliminary (our study began July 2001), we have identified nearly 20 OR genes from both Leatherback and Loggerhead Sea Turtles, about 10 OR genes from Green Sea Turtles, and 6 OR genes from alligators; these numbers are increasing as work continues. What is this new information telling us, and how can we use it?

## The Nature of Sea Turtle ORs

Sea turtles have ORs that are both similar to and distinct from the ORs of other vertebrates (see Figure 4). Initially, we identified sea turtle ORs by comparing their sequences with those of other vertebrate species. Sea turtle ORs are more similar to those of

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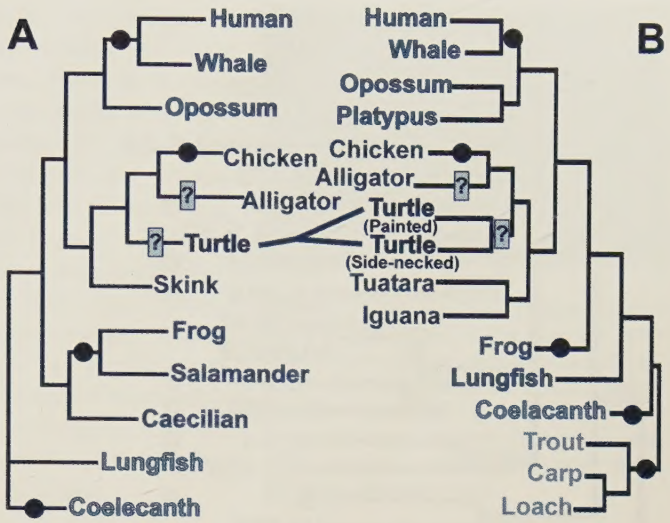



Figure 3. Current views of the evolutionary relationships of these animals, indicating the relatively close relationship between turtles, birds and reptiles (Zardoya & Meyer, 1998 (B), 2000 (A)). Vertebrates include about 45,000 of the 1.5 million known species of plants, animals, etc. on the planet. Fish, amphibians, birds and reptiles (including turtles), and mammals appeared about 450, 365, 300 and 220 million years ago respectively. Odor receptors are known from those lineages marked with filled circles. Nothing is known of odor receptors from turtles or reptiles ("?").

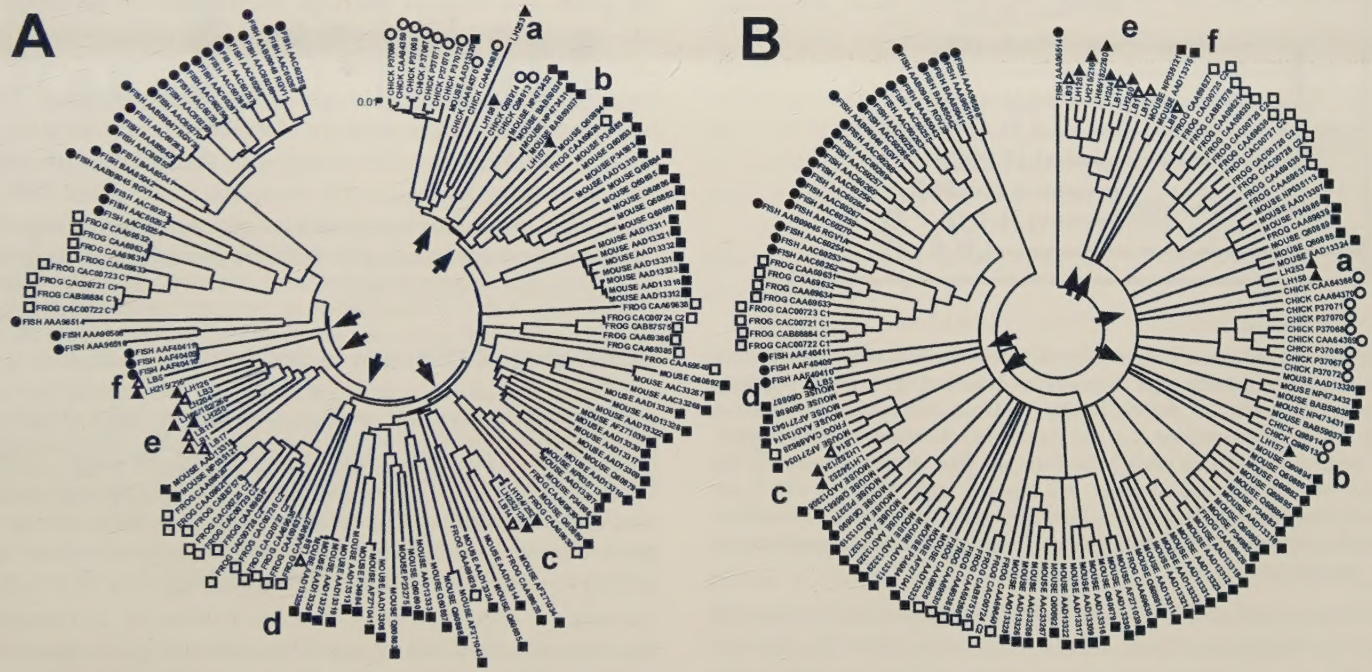



Figure 4. Comparison of Loggerhead and Leatherback OR sequences with those of other vertebrates. Amino acid sequences of proteins were first aligned; subjected to a computer program (Clustal W; Thompson et al., 1997) that makes a large table in which each protein occupies one row organized so that equivalent amino acids are in the same columns. The table is then subjected to a second computer program (MEGA2; Kumar et al., 2001), which tries to identify which sequences are most similar. The result is a dendrogram in which supposedly related sequences are found in the same branch. In this figure, ORs of Loggerhead (LH, filled triangles) and Leatherback (LB, open triangles) Sea Turtles are compared with all known OR sequences of zebrafish (FISH, filled circles), xenopus (FROG, open squares), chicken (CHICK, open circles) and mouse (MOUSE, filled squares. Arrows and letters (a-f) help locate turtle sequences. In A, branch lengths are proportional to the amino acid difference in the sequences. In B, branches are only shown for those relationships considered statistically meaningful ("50% bootstrap, 10,000 replicates"), branches are not proportional. In this analysis the dendrograms were made by a method called "neighbor joining."

New Discoveries (continued from page 7)

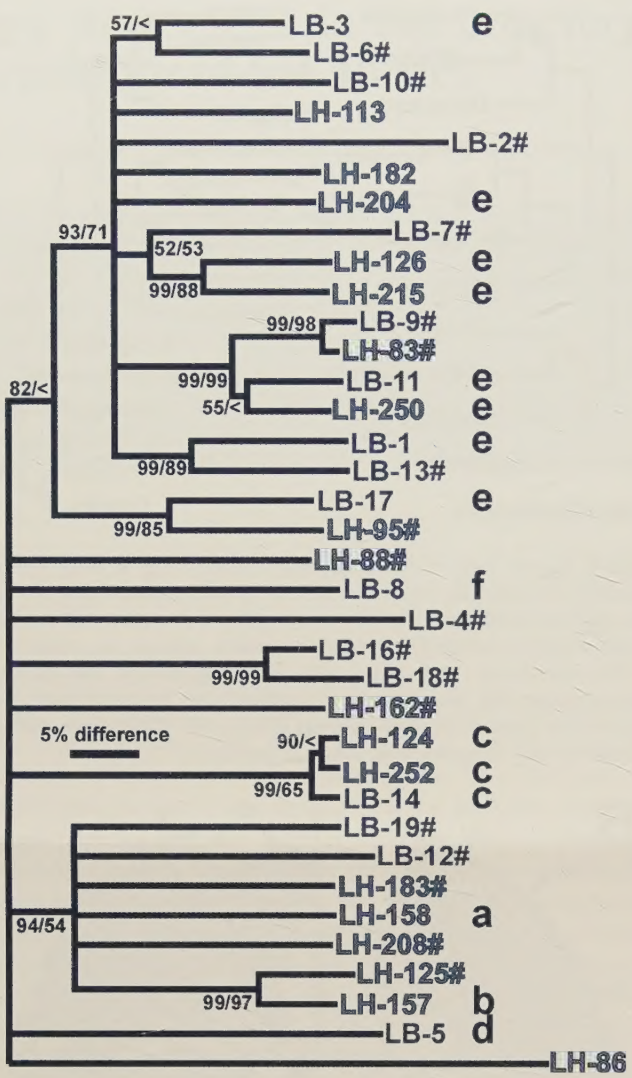



**Figure 5. Comparison of Loggerhead and Leatherback OR sequences. Nucleic acid sequences (genes) were compared as described in Figure 4. Sequence names marked with "#" contain defects ("internal stop codons") suggesting that they are not expressed (i.e. non-functional). Numbers indicate statistical support ("bootstrap value") for branches from different analyses; the higher the number the stronger the support (only branches >50% are shown). Letters (a-f) identify the same sequences as in Figure 4. A dendrogram is a neighbor-joining tree, in which branch lengths are proportional to the sequence difference.**

mammals, birds and frogs than they are to fish, which is consistent with the evolution of these animal groups (Figure 3). But sea turtle ORs also are distinct enough to fall into turtle-specific groupings. Important for our subsequent analyses, the sea turtle ORs fall into several groupings, distributing with a range of OR types from other vertebrates. Assuming that one can relate protein sequence to protein function, this distribution suggests that we have identified OR genes that have a broad functional repertoire.

Our analysis indicates that at least half of the OR genes in the sea turtle genome do not function at all (see Figure 5). When our cells make proteins, the gene DNA is first copied into mRNA, and the mRNA is then translated by ribosomes that assemble the protein. The mRNA contains a stop signal ("stop codon") that tells the ribosome when the end has been reached. More than half of the sea turtle OR sequences we have analyzed have incorrectly placed stop codons, indicating that if these genes were expressed, their products (proteins) would not work. Non-functional OR genes are not uncommon, but tend to occur in specific vertebrate groups, and are thought to represent a secondary loss of genes rather than an incomplete initial gain of genes. In primates, including humans, only about 30% of OR genes are functional (Rouquier et al., 2000; Zozulaya et al., 2001). All identified OR genes in dolphins are non-functional, consistent with their reduced olfactory bulb and suggestions that dolphins lost their sense of smell when their ancestors became aquatic (Freitag et al., 1998). On the other hand, most mice OR genes are functional. A reduced population of OR genes in sea turtles is certainly curious, and may reflect an alteration in their olfactory capability that accompanied a transition from terrestrial life to marine life.

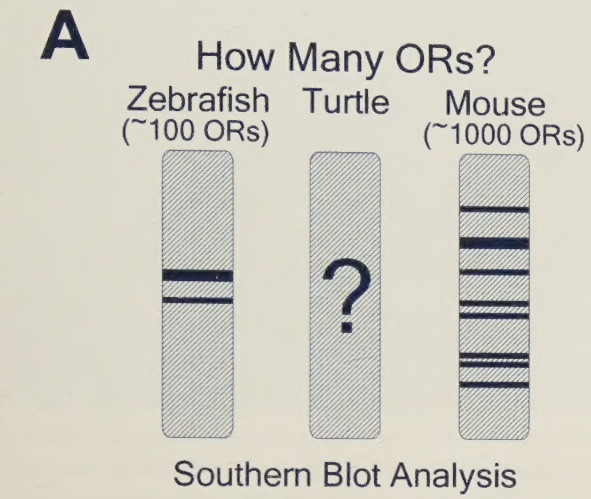
## Number of OR Genes in Sea Turtles

We are nearing the end of our initial phase of identifying OR genes in our chosen species. We can now estimate the number of OR genes, and compare this with the numbers of expressed vs. non-expressed OR genes (see Figure 6A). This will provide an estimate of the olfactory potential of these animals and of the diversity of odor molecules they might be capable of detecting. These experiments will involve southern blot analyses comparing the sea turtle OR hybridization complexity with that in zebrafish, which have about 100 OR genes, and in mice, which have about 1000 OR genes. This may provide important additional insights regarding when exactly the expansion of OR genes occurred in the evolutionary history of vertebrates.

## Significance of Olfaction in Sea Turtles

This is the ultimate question. Multiple versions of the same gene exist in a population of animals, providing some of the bases for individual variation; these gene versions are called "alleles." Geneticists identify distinct populations of members of a given species by comparing the ratios of different alleles of specific genes; distinct ratios imply a low level of interbreeding and gene mixing between two populations. We can use this technique to estimate the importance of OR genes in behavior, by comparing the sequences of alleles of several specific OR genes from many individuals of a population (see Figure 6B).

High allelic diversity would result from a lack of selective (behavioral) pressure favoring any one gene form, and would indicate that olfaction may not be that important. But if allelic diversity is low, with one form predominating over the others, we may hypothesize that there is significant selective pressure favoring one form over the others, and that olfaction is important in the animal's behavior. Many individual blood samples already exist from



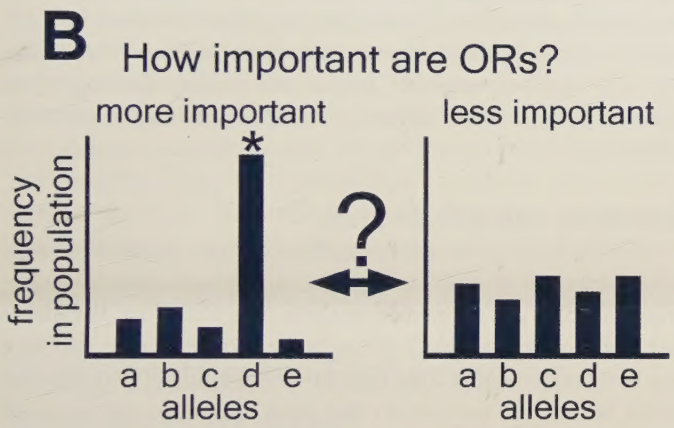




**Figure 6A. The number of OR genes in an animal can be estimated by performing Southern Blot Analysis. Genomic DNA (i.e. chromosomes) is isolated and enzymatically degraded in a controlled manner, after which the resulting fragments are separated by electrophoresis. A DNA probe (e.g. a turtle OR gene) is used to identify similar sequences. The number of bands reflects the number of genes.**

**Figure 6B. The importance of ORs in an animal's life can be estimated using population genetics. All genes are present in a population of animals in multiple forms, called alleles (one of the main reasons we are all different). Comparing the sequences of a specific OR gene from many individuals identifies the ratio of different alleles in the population. An unusually high proportion of one allele suggests that allele is better for the animal in some way and that the gene is playing an important role in the life of the animal.**

populations of Leatherback and Loggerhead Sea Turtles and are available for such analysis.

## The Value of Olfactory Based Management

Management of endangered or threatened species such as sea turtles requires a gentle hand. We believe that the importance of chemosensory information can be assessed non-invasively through molecular analysis of pre-existing tissue samples. The approach outlined can be applied to any animal species. In this study, our molecular experiments are being performed in parallel with careful behavioral studies by Drs. Yonat Swimmer and Richard Brill (NMFS, Honolulu) (see Figure 7). Together, these projects will clarify how Sea Turtles' chemo-sensory systems can be exploited to maintain a more effective distance between turtles and longline fishing gear.

**Figure 7. Testing the chemosensory response of Green Sea Turtles: in this case, the turtle is attracted to chopped squid inside the black plastic container that obscures visual characteristics of the squid. The experiments were conducted as a component of this project by Yonat Swimmer and Richard Brill, NMFS, Honolulu, December 2001.**

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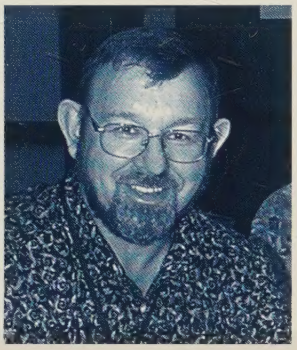
# MHLC7— Evaluation and Comment

*Following is the fourth in a series of commentaries on the Multilateral High-level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (MHLC). The goal of this series is to share the evaluations of scientists and other parties who are well informed about the MHLC, its Convention, Preparatory Conferences and evolving Commission, in the hope that continued frank discussion can contribute to the most effective and mutually agreeable implementation of the Convention.*

*We have accepted the assessments of persons recommended as knowledgeable about MHLC7 and are seeking additional comment. Our principal criteria are that contributors are familiar with the proceedings, the science and the proposed management schemes, and are willing to answer a common set of questions, with an opportunity for open comment.*

*Comments, questions, and requests for inclusion as a contributor may be addressed to Editor, PFRP News, 1000 Pope Road, MSB 313, Honolulu, Hawai'i 96822, or e-mailed to andercox@hawaii.rr.com, or jsibert@soest.hawaii.edu.*

*Robin Allen*



The MHLC was conducted to negotiate an international fisheries management arrangement for the stocks of highly-migratory fish in the Western and Central Pacific Ocean (WCPO). While the Conference succeeded in the sense of adopting a Convention, there is still much to be done before a management arrangement that is supported by all participants in the MHLC is achieved. There will not be an accepted framework for conservation and management until the major fishing states and the coastal states agree to cooperate within the framework of the Convention. Until then, the objective of the Conference will not be achieved.

While these issues are being resolved, institutional arrangements for data collection and research apparently are being set back. In the aftermath of the Convention, research cooperation seems to have diminished, and some positions for alternative arrangements seem to be developing. However, that is not to say that the objectives will not be achieved eventually. It is possible that sufficient differences in the positions that remained after the MHLC can be resolved with further patient negotiation to bring about the sought-after cooperation.

Against that background, I offer my thoughts on the facilities for data collection and research envisaged by the Convention. The Convention establishes a Scientific Committee composed of representatives of members of the Commission[1], and contemplates that the Commission would engage external scientific services. This takes a middle ground between conventions such as that of the Inter-American Tropical Tuna Commission (IATTC), which provides for a permanent scientific staff, and others that establish scientific committees but not permanent scientific staffs reporting to those commissions. The contrast between the two extremes is not as sharp as it was formerly, as other commissions have strengthened their own technical staffs, and IATTC stock assessments and other scientific advice are now reviewed by a scientific working group composed of representatives of member and interested countries. Apparently these developments acknowledge the utility of both a scientific staff and a scientific committee.

## Contracting Scientific Services

The scientific services contemplated by the Convention could be implemented in various ways that would have different implications for data collection and research. The following comments refer to the outcome that I see as being most effective: that is, a long-term relationship with a group who could act in a manner similar to that of a permanent staff. At a minimum, the duties of such a group would include stewardship of the Commission's data, and provision of stock assessment and scientific advice.

This would require a larger Commission budget than an arrangement with more modest scientific services. However, it does not necessarily imply greater costs for members of the Commission, who have the common obligation of providing data and scientific information to help manage the fishery. Without a central service, the members would have to contribute data management and stock assessment individually, through their own internal resources. In fact, a dedicated team with an overview of the entire fishery would be able to meet those needs more efficiently; such a team would be able to deploy resources effectively and avoid unnecessary duplication of effort.

In addition to efficiency, a contracted scientific service has other advantages for most members of the future Commission. An organization providing contracted scientific services would be equally responsible to all members. This would assure states that contribute detailed catch and effort data that their data would be used for scientific purposes without disclosing confidential information to others. Further, the likely members of the Commission range from states with well-developed scientific facilities to those with minimal facilities. While scientists always aim to provide objective results, experience in fisheries commissions indicates

[1]The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean.

that there is a tendency for the agendas and perspectives of scientific delegations to reflect national views. Also, the views of those with the best-developed scientific facilities are likely to dominate the Scientific Committee. Contracted scientific services can balance this asymmetry of advice, and provide all members with an independent source of scientific expertise.

A contracted scientific service could also provide support for data collection and biological research, although the arguments for doing this are less compelling than those for data management and stock assessment.

### How Big a Budget?

The question that is yet to be answered is the budget needed to provide adequate scientific services. The IATTC (because the author is familiar with this organization's budget) could be used as a guide for this. The costs of contracted scientific services are likely to be similar to those of a permanent staff. The IATTC currently has a research budget of about US$3 million (excluding dolphin-related work), which provides for data collection and management, biological research, and stock assessment. The stock assessment focuses on yellowfin, bigeye and skipjack tunas, with less intensive research directed toward bluefin tuna and billfish.

The new Commission similarly will need to have access to assessments of all the stocks of highly-migratory species in the convention area, especially those that are fully exploited or nearly so. Due to the significantly greater size of the fisheries in the WCPO relative to those in the Eastern Pacific, the data management responsibilities are likely to be more complex and costly than those of the IATTC. Even if contracted scientific services do not include data collection and biological research, funding on a scale similar to that of the IATTC would be necessary.

The Convention spells out the obligations of members to contribute necessary data, and establishes a regional observer program and a vessel-monitoring system. If these facilities are implemented, the new Commission will start with an unrivalled access to data, which will augur well for the scientific understanding of the resources and their fisheries. However, the key to cooperation and data provision is, of course, not the language of the Convention, but the willingness of participants in the fishery to trust one another and work together for the common good. At the moment the prospects for that seem bleak.

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## Compendium—Fisheries Research in Brief

### SCTB Returning to Honolulu

The Fifteenth Meeting of the Standing Committee on Tuna and Billfish (SCTB) will be hosted by the PFRP in Honolulu July 18–27, 2002—and is expected to attract special attention because the nascent Western and Central Pacific Fisheries Commission (of the MHLC) will be indirectly seeking SCTB advice on the status of major tuna stocks in the region.

The MHLC (Multilateral High-level Conference for the Conservation and Management of Highly Migratory Fish Stocks in Western and Central Pacific) concluded in Honolulu in September 2000 with its namesake treaty. This treaty created a Preparatory Conference (PrepCon) to establish the Commission, which is intended to help implement the provisions of the treaty.

The second session of the PrepCon was held late in February in Papua New Guinea. Among its conclusions was a decision to establish a "Scientific Coordinating Group" (SCG) to receive information on the status of skipjack, yellowfin, bigeye and southern albacore tuna, and provide interim management advice to the PrepCon. The first meeting of the SCG will follow SCTB15 on June 29 & 30 at the East-West Center in Honolulu.

Further details and a provisional agenda for SCTB15 can be found on the PFRP website, and an article descriptive of SCTB14 can be found in the October–December 2001 issue of the PFRP newsletter (vol. 6, no. 4). A full report of PrepCon 2 will appear in the next PFRP newsletter.

### MHLC Grows in Membership/Funding

The Chairman of the Preparatory Conference for the Multilateral High-level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (MHLC) announced on January 24 that the Republic of Korea donated US$50,000 to support the Government of Papua New Guinea as host of the second session of the PrepCon. The donation represented Korea's contribution to the PrepCon Organizational Fund, and was made on the same day that Papua New Guinea allocated Kina 100,000 as its contribution to the Fund.

In addition, the PrepCon Secretariat announced that it had received a written petition from the State Committee for Fisheries of the Russian Federation requesting an invitation to participate in PrepCon deliberations. Vyacheslav Volokh, the Federation's Committee Deputy, noted in the petition that the Federation is a coastal country within the area of the

(continued on page 12)

Compendium (continued from page 11)

Convention, that it is able to fish for tuna in the area, and that it therefore is lawfully entitled to participate in the process of determining conservation and management measures as provided in UNCLOS–1982, and in the FAO Code of Conduct for Responsible Fisheries–1995. The Secretariat resolved to consider the petition during PrepCon 2, recently concluded in Papua New Guinea.

## Fishing Scars Atlantic Reefs

New research suggests that fishing trawlers are smashing ancient coral reefs in cold, deep waters of the Northeast Atlantic—and marine scientists are calling for urgent protection of the unique and poorly understood reefs. "The best way to protect these areas is a blanket ban on bottom trawling," says Jason Hall-Spencer of the University Marine Biological Station. Coral experts hope a forthcoming overhaul of European Union fishing rules will provide an ideal opportunity to impose such a ban. For details, see: Hall-Spencer, J., Allain, V. and Fossa, J. H. "Trawling damage to Northeast Atlantic ancient coral reefs." Proceedings of the Royal Academy of Sciences B, online publication DOI: 10.1098/rspb.2001.1910 (2002).

*(from* Nature, *Science Update, 26 February 2002)*

## Reserves Bolster Fish Stocks

Researchers have concluded that banning fishing in some areas does indeed boost catches in others. Fisheries in the Caribbean and Florida have become more productive since marine reserves were established, despite fishermen having fewer areas to fish in. The idea that such reserves help fishing has been controversial. "There hasn't been good evidence that reserves will benefit surrounding fisheries," says Callum Roberts, a conservation researcher at the University of York, UK—but he thinks his latest research provides that evidence. For details, see Roberts, C. M., Bohnsack, J. A., Gell, F., Hawkins, J. P. and Goodridge, R. "Effects of marine reserves on adjacent fisheries." *Science*, 294, 1920–1923, (2001).

*(from* Nature, *Science Update, 30 November 2001)*

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